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NUMERICAL SIMULATION OF WAVE-INDUCED SCOUR AND BACKFILLING BELOW SUBMARINE PIPELINES

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A fully-coupled hydrodynamic and morphodynamic numerical model is utilized for the simulation of wave-induced scour and backfilling processes beneath submarine pipelines. The model is based on solutions to incompressible Reynolds-averaged Navier-Stokes equations, coupled with k-ω turbulence closure, with additional bed and suspended load descriptions forming the basis for sea bed morphology. The morphological evolution is updated continuously, rather than being based on period- or other time-averaging techniques. For further details regarding the sediment transport and morphological models, see Jacobsen et al. (2014). Wave motions are driven as oscillatory flows, as described by Liang & Cheng (2005).

Simulations (using laboratory scales) involving wave-induced scour over the range of Keulegan-Carpenter number 5.6 ≤ KC ≤ 30 have been conducted. Two examples are illustrated in Figure 1, depicting the time series of computed scour specifically for KC=5.6 and KC=30. On both plots the horizontal dashed line indicates the target scour depth, based on the experimentally-based regression equation of Sumer & Fredsøe (1990): $S/D=0.1(KC)^{0.5}$. Here S is the scour depth directly beneath the pipeline center, D is the pipeline diameter, and t* is a dimensionless morphological time. As seen, the model consistently predicts equilibrium scour depths that are in line with experimental findings, demonstrating a clear tendency for increased scour as KC grows. Similar accuracy has likewise been found for predicting wave-induced scour with intermediate KC values, as well as for the corresponding scour time scales.

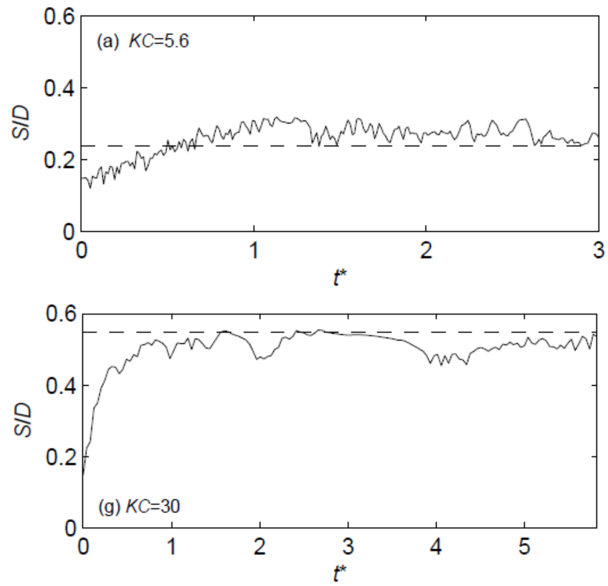

Figure 1 – Time series of computed wave-induced scour depth with (top) KC=5.6 and (bottom) KC=30

Wave-induced backfilling processes have additionally been studied by subjecting initial conditions taken from scour simulations with larger KC to new wave climates characterized by lower KC values. A single example is demonstrated in Figure 2, which depicts the computed scour depth following a change in wave climate from KC=30 to 5.6. As seen, the model predicts backfilling towards the expected equilibrium scour depth based on the new wave climate, in line with experimental findings of Fredsøe et al. (1992). The simulated backfilling time scales are the same order of magnitude as in experiments, though the observed two-stage backfilling process (e.g. Figure 2) complicates a more systematic characterization.

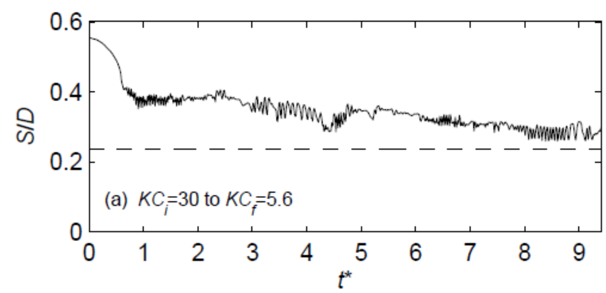

Figure 2 – Time series of computed scour depth after a change in wave climate from KC=30 to KC=5.6

The simulated model-scale sequences of scour and backfilling, e.g. combining Figure 1 (bottom) and Figure 2, have been estimated to represent temporal durations the order of individual storms at full practical scales.

REFERENCES

Fredsøe, Sumer, Arnskov (1992): Time scale for wave/current scour below pipelines. Int. J. Offshore Polar Eng. **2**, 13-17.

Jacobsen, Fredsøe, Jensen (2014): Formation and development of a breaker bar under regular waves. Part 1: Model description and hydrodynamics. Coast. Eng. (in press).

Liang, Cheng (2005): Numerical model for wave-induced scour below a submarine pipeline. J. Waterw. Port. C-ASCE **131**,193-202.

Sumer, Fredsøe (1990): Scour below pipelines in waves. J. Waterw. Port. C-ASCE **114**, 599-614.